Model 102B Analog Network Analyzer Operator's Manual



•AP Instruments Inc.

Model 102B 0.01 Hz - 15 MHz Analog Network Analyzer

MANUAL REVISION 4.0F WINDOWS VERSION 3.0 SOFTWARE Copyright 2000

• AP Instruments

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Federal Communications Requirements

Warning- This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a class A computing device pursuant to Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in residential areas is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

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Copyright Notice

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System Installation

The Model 102B Network Analyzer

IBM® PC AT computer. the source/receiver unit, probes, interface cables and software for a user provided unit, a digital signal processing (DSP) board with an on-board power supply for The 102B Network Analyzer system is composed of an analog source/receiver

features The 102B Network Analyzer offers the following high performance

- 11.6 millihertz to 15 Megahertz coverage 110 dB's of dynamic range with 0.025 dB mag. and 0.1 degree phase accuracy
- Automatic magnitude and phase correction compensates for test leads or Up to 2001 measurement points with linear or logarithmic frequency sweeps

Graphical interface features

- Windows® based graphical user interface
- Virtual instrument front panel for complete access to all system parameters
- Automatic or manual scaling and shifting of screen plots for optimum viewing applications Dynamic Data Exchange (DDE) interface for data sharing between

Two movable markers and master graphs give data and delta readouts.

Advanced functions including complex impedance and IEC 555-2 display

- Source features
- Direct digital synthesis for fast sweeps
- Output level adjustable in 1 dB steps from 1.25 millivolts to 1.77 volts rms 11.6 millihertz to 15 MHz range, 11.6 millihertz resolution
- 50 ohm output with current limiting
- at low measurement frequencies Output can be DC offset up to +/-10 V eliminating large coupling capacitors

Receiver features

- Two channels for B/A ratioed, transfer function measurements
- High selectivity two stage receiver architecture for high noise immunity
- Digital signal processing provides a user selectable IF bandwidth, optimizing noise immunity and measurement speed
- Selectable AC (>=10 Hz) or DC coupling with one megohm input impedance
- Inputs can be DC offset up to +/-10 V facilitating DC coupled measurements.

Host PC requirements for using the Windows software

Minimum Configuration: Windows version 3.1 or Windows 95. 80386 processor or higher with math coprocessor. 4MB RAM (Windows 3.1) or 8MB RAM (Windows 95), 1.5 MB hard disk space. Mouse and VGA monitor.

Hardware Installation

The DSP board needs one full size 16 bit slot from the host IBM® PC AT compat ible computer. The PC's CPU must be an 80386 or higher. A math coprocessor is also required. The host PC is also required to have a floppy drive, Windows® 3.1 or higher, 4 Meg RAM, mouse and a VGA or better display adapter.

The unit requires 1.5 amps from the PC's +12v power supply or an external supply rated 30w or greater. The minimum recommended PC power supply is 150W which generally translates into a +12v supply of 6 amps or greater capacity. This allows the usual complement of one hard drive and one floppy drive.

CAUTION !

Before handling the DSP board make sure you are in a static free work environment, preferably wearing a grounded wrist strap, or at a minimum, taking care to discharge any static electricity by touching a grounded, conductive, object. When operating the analyzer static discharge precautions must be taken to prevent damage to the source or receiver channels. This includes wearing a grounded wrist strap and using a grounded static control table mat.

CAUTION !

The analyzer must first be powered on before connecting to a circuit that has a nonzero voltage at the measurement points. Do not leave an unpowered analyzer connected to powered circuits.

WARNING !

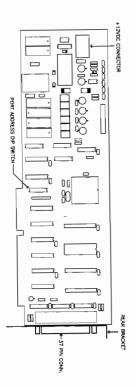
DO NOT ATTEMPT TO MAKE MEASUREMENTS ON HOT OR UNGROUNDED SYSTEMS!!!. DO NOT ATTEMPT TO SHIFT THE SOURCE/RECEIVER GROUND BEYOND THE VALUES GIVEN OR THE SOURCE/RECEIVER UNIT WILL BE DAMAGED!!!. If it is necessary to make measurements on such systems then use an isolation transformer on the system and ground the system under test to an earth ground. See application notes for high common mode voltage measurement procedures. Working on or around line voltages has electrical shock hazards for both the operator and the instrument that must be understood before measurements are attempted!

Installation Procedure

After ensuring the host PC has met the minimum requirements given above follow the directions below:

- [1] Make sure the PC's power switch is turned OFF and gain access to the PC's card cage area by removing the necessary covers.
- [2] Identify a free 16 bit slot (two edge connectors). The selected slot should also have an empty slot next to it on the component side to maximize airflow to the DSP board's power supply. Remove the selected slot's existing rear card cage bracket, keeping the screw for the next step.

DSP Board Outline



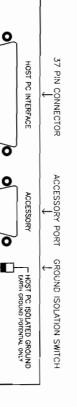
After taking the proper static safeguards as outlined above grasp the DSP board at the upper left and right edges, avoiding any components. Push the DSP board into its slot firmly at which point the mounting bracket clearance hole should be aligned with PC's card cage threaded hole. Use the screw saved from step 2 to secure the card in place.

[3]

Using the included Y adapter cable if necessary, connect the PC's power supply harness to the DSP board's receptacle. The Y adapter can be used if there are no free power supply harness plugs by removing a plug from a disk drive and replacing it with the Y adapter plug, reinstalling the power supply harness plug into the Y adapter's receptacle. Use the end with the three wires, two black and a yellow, to plug into the DSP board.

4

Source / Receiver Rear Panel



[5] Reinstall any covers, or sheet metal, previously removed.

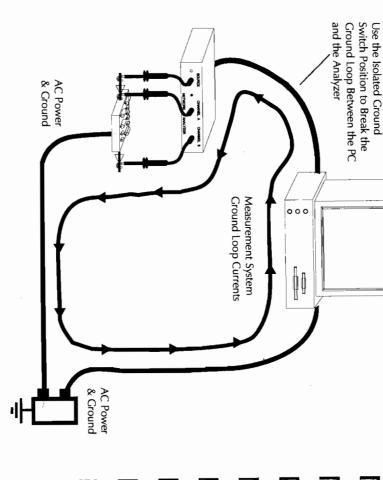
MADE IN USA

GROUNDING POST

GROUND

- [6] Push in the 9 foot cable's 37 pin plug, the end marked "PC", into the DSP board's receptacle and secure the two screws. Likewise, connect the other end to the source/receiver unit.
- [7] Set the ground isolation switch to the desired position. This switch allows the user to isolate the source/receiver ground from the host PC ground thus preventing ground loops which may introduce measurement errors. This situation is pictured on the next page. Differential drivers and receivers are used which give about 15K ohms of isolation. PC's have switching power supplies whose line filter inject currents into the PC's

Measurement System Ground Loop



ground wire. Since these currents are at the switching frequency, typically 30 kHz or more, the ground wire impedance will cause the PC's ground to have a noise of several hundred millivolts. For circuits that are unpowered, i.e. passive, the HOST PC GROUND (not isolated) position may typically be chosen. If the isolated position is chosen then the source/receiver unit must be grounded, using the ground post, to a point where the voltage potential is within +10 and -5 volts of the PC ground. The ground should be connected to the test circuit's power supply ground. The test circuit's power supply ground and the PC ground connections should be arranged so as to minimize their common mode impedance.

Source / Receiver Front Panel



Connect the source probe, a 1:1 cable with clips, to the source output BNC. Connect the two input probes, labeled "A" and "B" to their respective BNC's.

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Software Installation

Installing the Windows software for the first time

- [1] Insert the software disk labeled "AP Instruments Windows Software for the Model 102A/B Network Analyzer, Version 3.0" into the host computers floppy drive.
- [2] While in Windows, use the program manager's RUN command to execute the setup program "a:\setup" or "b:\setup" depending on the PC's floppy drive letter designation a: or b:. Choose the "First-time Software Installation (Full Install)" option. The setup program will create a directory

AC Mains Ground

(default location of C:\nawincon) and transfer the required program files to this directory. The setup program will also create a program group called "AP Instruments".

 Ξ at the bottom side of the DSP board. Another generally available port is number of the source/receiver unit and the DSP board's port address. software make sure the analyzer hardware is properly installed in the hos is located within the AP Instruments program group. Before starting the s2*256 + s3*128 + s4*64 + s5*32 + s6*16 + s7*8the OFF position to be a multiplier of 1 the port address(dec) = s1*512 + 10ON OFF ON. Taking the switch ON position to be a multiplier of 0 and 784 decimal (310 Hex) given by the DIP switch set as OFF OFF ON ON with the switch positions read from left to right as 1234567 with switch 1 position DIP switch. The factory setting is OFF OFF ON ON ON ON ON addresses then a new port address can be set on the DSP board's 7 problems are encountered after installation that suggest conflicting port must reflect the actual address switch settings on the DSP board. If 300 Hex (768 Decimal). The port address selected in the program first time will bring up a dialog box prompting the user to enter the mode Connectivity icon will start the software. Executing this program for the PC and all cables are connected. Double clicking on the NA Windows The Windows analyzer software icon, named NA Windows Connectivity The DSP Board's port address DIP switch has been preset at the factory to

The program, NA Windows Connectivity, will allow power to the source/receiver unit (as will be evident by the red power indicator LED). At this point the virtual control panel will be available and the installation is complete. The power to the source/receiver unit will automatically switch off at program termination, or if a hard reset is performed or, of course, if the PC's power is cycled off-on.

IMPORTANT NOTICE!

It is recommended that the source/receiver unit be positioned, by at least severa feet, away from the PC and the PC's monitor (CRT). These units generate strong magnetic fields that can cause erroneous measurement results. Also, do not set heavy objects on the source/receiver unit.

Updating from an earlier version of the Windows software

- [1] Insert the software disk labeled "AP Instruments Windows Software for the Model 102A/B Network Analyzer, Version 3.0" into the host computers floppy drive.
- While in Windows, use the program manager's RUN command to execute the setup program "a:\setup" or "b:\setup" depending on the PC's floppy drive letter designation a: or b:. Choose the "Software Update" option. The setup program will locate your existing software and update the necessary files.

[2]

Graphical User Interface

NA Windows Connectivity Overview

The Network Analyzer (NA) Windows Connectivity program provides the interface to the network analyzer. This interface allows complex problems to be solved quickly by integrating the following key components into an intuitive environment:

- A virtual front panel for Instrument control.
- A graphics display which plots the acquired data in a variety of formats, called display modes and provides real-time data analysis through markers and master traces.
- Control over system attributes such as graph colors and data format
- Data exportation. Measured data is made available to other applications through the clipboard (as static data) and through Dynamic Data Exchange (DDE) so that real-time user defined post processing is possible.
- Environment persistence. Save and restore all the display attributes and analyzer parameters (including special calibrations) for a particular measurement configuration.

Virtual Front Pane

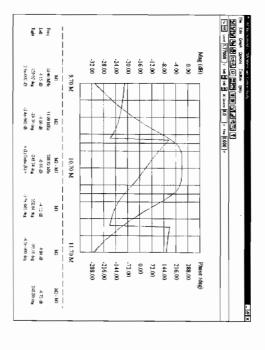
Nearly all functions relating to the operation of the Network Analyzer are available on the toolbar. The toolbar is divided into a upper and lower toolbar. The upper (main) toolbar contains controls for the general operation and display of the network analyzer. The main toolbar is always visible. The lower toolbar is used for instrument parameter entry and is one of four toolbars, as selected by the operator from the main toolbar.

All parameters take effect immediately as they are selected. The exception to this are the edit boxes which include start & stop frequency, sweep points, averaging factor, user dwell value, source output level & DC offset. These edit boxes have their values updated by hitting the Carriage Return (Enter) or Tab key.

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Graphics Display

The graph display has four basic modes of display. A particular mode is selected using the *graph* menu. The four modes are as follows: Magnitude and Phase, Absolute Magnitude, Complex Impedance, and IEC 555-2. Each graph mode maintains its own separate system wide parameters. This allows the operator to change parameters such as start and stop frequency in one mode without it affecting the start and stop frequency in another mode.



Graph Trace

The graph trace is plotted in real time for the first sweep and then after the end of each sweep for the remaining sweeps. The graph can display two separate data traces simultaneously, distinguishable by their color. These datum can be displayed together or singularly by using the left and right trace display selectors available through the [Options | Trace Display...] dialog box or the toolbar. The trace colors can be selected by using the [Options | Color...] dialog box the

the axis scaling or the marker readout can be changed using the [Options | on the left and right ordinates. The format of all numeric data displayed for either selection or toolbar buttons. The axis scaling for each trace is indicated separately automatically using the [Graph | Manual Scale...] or [Graph | Auto Scale] menu Format Data...] dialog box. minimum and maximum range of the graphed data can be chosen manually or

Markers

M1, is also displayed along with the data at M1 and M2. depressing the right mouse button. The difference between the markers, M2 the mouse left or right as desired. The second marker, M2, is moved similarly by The first marker, M1, is moved by depressing the left mouse button and moving are first enabled by using the [Graph | Markers] menu selection or toolbar button The graph display markers consist of a vertical line for each marker. The markers

Master Trace

active data trace separately for both left and right traces of the active trace marker data readout. The delta data readout, displayed at the as the master trace. The master trace marker data readout is displayed to the righ bottom of the graph window, gives the difference between the master and the button). When master traces are selected the current active trace data is copied use the [Graph | Master Curves] menu selection (or the master trace toolbar Also available within the graph display are master traces which allow comparisons between a stored trace and the active trace. To add master traces to the display

Graph Display Modes

Magnitude and Phase

tude indicates attenuation. The phase display range can be chosen through the gain through the network under test (i.e. B>A) while a negative value of magniwhile the phase is expressed in degrees. A positive value of magnitude indicates channel B divided by channel A. The magnitude represented is expressed in dB The first display mode, magnitude and phase, graphs the ratioed measurement of

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ing the linearity of the network under test degrees. The phase shift indicates the relative phase shift from channels A to B. however, become important for optimizing the signal to noise ratio and preserv-Note that the source level does not enter the equation. The source level does, [Options | Format Phase...] dialog box to be either a range of \pm 180 or 0 to 360

Absolute Magnitude

surement by showing the actual (absolute) signal strength of each channel. displaying it in RMS volts. This mode is useful for diagnosing a noisy B/A mea-The second display mode, measures the absolute magnitude of channels A and B

Complex Impedance

manner (see application note on measuring complex impedance). The reference when using an external reference resistor connected to the network in a specific displayed as one of the following : resistor value is entered as a parameter. The complex impedance, L, can be The third display mode graphs the complex impedance of a network under test

Magnitude and Phase of Z Real Z and Imaginary Z

Equivalent Capacitance and Resistance

Equivalent Inductance and Resistance

A choice of series or parallel circuit models are available.

bandwidth is required to be flat from 50 Hz to 2.5 KHz. is entered as an input parameter. The current transducer frequency response measured using an external current transducer whose sensitivity in Volts per Amp line current frequency is user selectable as 50 Hz or 60 Hz. The current is line current. This mode is intended for IEC 555-2 pre-compliance testing. The The fourth display mode graphs a plot of the first forty harmonics of the power

Menu Selections

File Menu

Open Data..

Opens a dialog box which allows previously saved sweep data to be loaded into memory and displayed in the graph window. Once in memory, sweep data is available for Clipboard Copy and, if a DDE Client is linked, the data will be sent to the client.

Save Data As..

Opens a dialog box which allows the current displayed sweep data to be saved as a text file. The data is written in the following format:

One line per data point, On each line are five (5) tab separated values ordered as Frequency, Magnitude (B/A), Phase (B/A), Absolute Magnitude (A), and Absolute Magnitude (B).

Data is saved with the extension .dat.

Open Setup..

Opens a dialog box which allows a previously saved configuration to be loaded. All parameters will be set to the new values.

Save Setup As...

Opens a dialog box which allows the current configuration to be saved as a text file. This setup can then be recalled using the *Open Setup...* command. Only the configuration of the selected display mode is saved. On exit, the current configuration is saved automatically in the file *nawincon.ini*, and loaded when the application is started again. Setup files are also maintained for each display mode automatically. Whenever the display mode changes a setup file is written for the current mode and a setup file is loaded (if exists) for the newly selected display mode. See *File Types*, *Use and Format* for more information.

Default Setup

Resets the setup configuration of the currently selected display mode to the default state.

Calibration...

Opens the Calibration File Maintenance dialog box which allows setting the pathnames of the network analyzer calibration files and the creation of new calibration files. To load an existing calibration file, click the Browse button and then choose the file to load. Clicking the Create button performs the calibration procedure and saves the new calibration data to a file. This newly created calibration file is automatically selected and used by the current graph display mode. See System Calibration for more information.

System Settings...

Opens the System Settings dialog box which displays the network analyzer model number and the software configured port address. The port address must reflect the port address dip switch setting on the DSP card. The system settings can not be changed while the application is running. To change the system settings:

- [1] Exit NA Windows Connectivity
- [2] Execute the Setup program from the software installation disk and choose the Hardware Configuration Change option.

Print...

Opens the standard print dialog box. The graph display window is printed using the selected print options. This command behaves differently than the toolbar print button which does not invoke the dialog box.

.

Exits the application. Sweep data in memory will be lost and any *DDE links* will be terminated. The current configuration is saved automatically.

Edit Menu

Copy

Copies sweep data to the clipboard. After executing this command the clipboard will contain the last full sweep, except during the first sweep which will copy only the current collected data. The sweep data will be copied with the same format

as in [File | Save Data As...] and using the selected phase format. This function is unavailable (grayed) when sweep data memory is empty. This function is also available on the Toolbar.

Graph Menu

Magnitude & Phase

Selects the Magnitude and Phase display mode. When this mode is selected the left trace will display magnitude B/A data in decibels and the right trace displays phase B/A data in degrees.

Absolute Magnitude

Selects the Absolute Magnitude display mode. When this mode is selected the left trace will display the absolute magnitude of channel A in volts and the right trace displays the absolute magnitude of channel B in volts.

Complex Impedance...

Selects the Complex Impedance display mode. When this mode is selected the Complex Impedance Setup dialog box appears which accepts complex impedance parameters, these parameters include:

Reference Resistor

The series resistor to the network under test.

Equivalent Circuit

Model the equivalent circuit as Series or Parallel.

From the dialog box a display view selection is made from the following:

Complex Impedance (Rect)

Display complex impedance in rectangular coordinates, Z(f) = X(f) + iY(f), the real part (X) on the left and the imaginary part

(Y) on the right.

Complex Impedance (Polar)

Display complex impedance in polar coordinates, Z(f)=R(f)A(f), the magnitude ($R=\lfloor Z \rfloor$) on the left and the angle (A) on the right.

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Equivalent Circuit (R & C)

Display the resistive (left trace) and capacitive (right trace) components of an equivalent (series / parallel) circuit.

Equivalent Circuit (R & L)

Display the resistive (left trace) and inductive (right trace) components of an equivalent (series / parallel) circuit.

Before the complex impedance setup dialog box is displayed a warning is issued. This warning is a reminder that to produce meaningful data, specific measurement configurations are required as described by Measuring Complex Impedance (Application Notes). An option to disable this warning is available in the dialog box.

IEC 555-2...

Selects IEC 555-2 display mode. Prior to displaying data the IEC 555-2 Setup dialog box provides for the following selections:

Line Frequency

The line frequency of the power supply

ensitivity

The sensitivity of the current to voltage converter (in volts per

Before the IEC 555-2 setup dialog box is displayed a warning is issued. This warning is a reminder that to produce meaningful data, specific measurement configurations are required as described by IEC 555-2 Measurements (Application Notes). An option to disable this warning is available in the dialog box.

Markers

Toggles graph markers. When enabled, the makers are visible and may be positioned by dragging the mouse with either the left (left marker) or right (right marker) button. The marker data is displayed below the graph.

Expand Markers

Sets the sweep start and stop frequencies to the current marker frequencies.

Master Trace

Toggles master traces. At the moment this is enabled, the realtime traces are copied and displayed as master traces. When makers are enabled, master trace marker data is displayed, this includes the difference (Delta) between the master and realtime trace.

AutoScal

Executes an automatic scaling procedure on both the left and right trace, then redisplays the graph. Only the realtime trace data is used for autoscaling. Thus it is possible that master trace data may lie outside the graph after autoscale.

Manual Scale..

Opens the Manual Scale dialog box in which graph scaling for the left and right trace is accomplished. When this dialog box opens, the current minimum and maximum values are displayed

Options Menu

1100...

Opens the *Craph Title dialog box* to provide a title for the graph. The title is displayed centered in the window above the graph. The title is defined for the selected graph display mode, and is only displayed within the graph mode. A different title may be defined for each graph display mode.

Colors.

Opens the *Graph Color Selection dialog box* where color selections are made for the graph display window elements. Each of the six graph elements, *Grid*, Markers, Left & right traces, and Left & right master traces may be one of sixteen colors. While graph markers are enabled the marker data is displayed. By default, marker data is displayed in the associated trace color, but may be displayed in black.

Format Data...

3

Opens the Format Data dialog box which provides formatting of the data displayed along side and below the graph. Data formatting is independently avail-

able for Frequency data, Left trace data, Right trace data, and Delta (Master trace minus the realtime trace) data. The three formatting options are as follows :

Standard

Numbers are formatted with the standard notation of comma's separating every three digits (i.e. 12,456,100.96).

Exponential

Numbers are formatted in exponential notation (i.e. 1.24 e07)

Engineering

Numbers are formatted in a scientific notation with the value always between 1 and 1000, a unit modifier is added to represent the decimal position (i.e. 12.45 M).

The number of displayed significant digits is entered in the sigfig edit box. The values above were formatted with sigfig = 2.

Trace Display..

Opens the *Trace Display dialog box* to select viewing left trace only, right trace only, or both left and right traces.

Format Phase...

Opens the Format Phase dialog box which allows the phase data to be presented in either the \pm 1.180° or 0-360° format.

Toolbar Menu

Sweep Frequency

Display the sweep frequency toolbar (pg. 23).

Sweep Parameters

Display the sweep parameters toolbar (pg. 24).

Source Parameters

Display the source parameters toolbar (pg. 25).

Receiver Parameters

Display the receiver parameters toolbar (pg. 26)

Help Menu

Contents

Executes the online help. This function is also available on the Toolbar.

About NA Windows Conn.

Opens a dialog box that displays program information such as the minimize Icon and version number.

The Toolbar

The toolbar is divided into a upper and lower toolbar. The upper (main) toolbar contains controls for the general operation and display of the network analyzer. The main toolbar is always visible. The lower toolbar is used for instrument parameter entry and is one of four toolbars, as selected by the operator from the main toolbar.

Main Toolbar



Start Sweep

Begins a sweep using the set parameters. Note: It is not necessary to click the OK button in the parameter window prior to starting a sweep, this will be done automatically. This function is also available from the sweep menu.

🔀 Stop Sweep

lerminates the sweep in progress. Sweep data is not accessible until a complete sweep is finished. This function is also available from the sweep menu.

Reset Sweep

Terminates the sweep in progress and begins a new sweep. This is the same as clicking Stop followed by Start. This function is also available from the sweep menu.

🖺 Сору

Copies sweep data to the clipboard. After executing this command the clipboard will contain the last full sweep, except during the first sweep which will copy only the current collected data. This function is unavailable (grayed) when sweep data memory is empty. This function is also available from the edit menu.

Print

Prints the graph display window on the default printer in landscape orientation. In order to print using alternate options use the print command from the file menu.

⊞ Markers

Toggles graph markers. When enabled, the makers are visible and may be positioned by dragging the mouse with either the left (left marker) or right (right marker) button. The marker data is displayed below the graph. This function is also available from the graph menu.

Master Trace

Toggles master traces. At the moment this is enabled, the realtime traces are copied and displayed as master traces. When makers are enabled, master trace marker data is displayed, this includes the difference (Delta) between the master and realtime trace. This function is also available from the graph menu.

Expand Markers

Sets the sweep start and stop frequencies to the current marker frequencies.

III AutoScale

Executes an automatic scaling procedure on both the left and right trace, then redisplays the graph. Only the realtime trace data is used for autoscaling. Thus it is possible that master trace data may lie outside the graph after autoscale. This function is also available from the graph menu.

Manual Scale

Opens a dialog box in which graph scaling for the left and right trace is accomplished. When this dialog box opens, the current minimum and maximum values are displayed. This function is also available from the graph menu.

TED Display Left Trace

This button controls the visibility of the left trace. By default the trace is visible (button pressed). This function is also available from the *Trace Display...* command of the options menu

Display Right Trace

This button controls the visibility of the right trace. By default the trace is visible (button pressed). This function is also available from the *Trace Display...* command of the options menu

"து தி.ஜி.ஜ்" Display Parameter Entry Toolbar

Select the lower toolbar to be one of the four parameter entry toolbars: Sweep Frequency Toolbar, Sweep Parameters Toolbar, Source Parameters Toolbar, or Receiver Parameters Toolbar.

% Help

Executes the online help. This function is also available from the help menu.

Sweep Frequency Toolbar

Sweep frequency limits may be entered as Start/Stop, Center/Span, or File list values.

III Start/Stop

Two edit boxes allow for sweep start and stop frequencies to be entered. Frequency values may be entered as standard values, with or without separating commas (ie. 100.2 or 1,200), exponential values (ie. 1.2e5), or with one of three standard SI prefixes: m-milli, k-kilo, M-mega (ie. 1k, 2.6M). After typing a new frequency value you must enter it by hitting the Carriage Return (Enter) or Tab key. Regardless of how the value was entered it will be converted to the comma separated format.

In the event the frequency value entered causes an error (value out of range or start frequency greater than stop frequency) a message box will be displayed and either value may be edited to remove the error. This is handy when entering a new sweep range which conflicts with the current sweep range.

+ Center/Span

Two edit boxes allow for the sweep range to be entered as a center frequency and the total frequency span. Frequency values are entered exactly as described in Start/Stop above.

File List

When File list is selected, a frequency points list (.fpl) file is used as the sweep frequency points. The filename is entered into the corresponding edit box either manually or selected through the Browse ([...]) dialog box.

A frequency points list file (file extension .fpl) has the following format:

A series of frequency values separated by a carriage return <CR> (i.e. one value per line). The frequency values may be in decimal or exponential format. The

sweep is accomplished by processing each point starting at the top of the file, therefore the value at any line in the file must be greater than that of the preceding line.

Sweep Parameters Toolbar

Lin Log	
Points 100	
Avg 🗆 20	
Dwell 🗆 🛭	
ms	

Mode Mode

If *Single* sweeps are enabled then the sweep activity is suspended upon collection of the last data point. A new single sweep is started by clicking the start sweep toolbar button or sweep menu option. If *Continuous* is selected then the sweeps are repeated continuously.

Lim Log Type

If Lin is enabled then the frequency increment between data points remains constant. The Log sweep mode gives a frequency increment between points that is logarithmically increasing with frequency thus compressing the frequency axis. Use the Log selection for Bode type plots. This parameter is not used when sweeping with a frequency points list file. The increment between each point is solely determined by each frequency point value.

Points

Enter the number of data points to collect. The maximum number of points is 2001. Available RAM may limit the number of points you can use. Approximately 25K Bytes of RAM are needed per 100 data points. This parameter is not used when sweeping with a frequency points list file. The number of data points will be equal to the number of frequency values in the file.

AVS

Sweep averaging is toggled on and off by clicking the Avg checkbox. The Averaging Factor specifies the weighting of each sweep into the displayed trace, is a value from 1 to 999, entered into the Avg edit box. The weighting of a sweep (weighting factor) is 1 / Averaging factor. When enabled, the averaging function

averages each sweep into the trace with a weighting factor equal to the sweep count, until the Averaging Factor is reached. When the specified averaging factor is reached, the trace is updated with each sweep weighted by the Averaging Factor.

Dwell

User specified dwell is selected by clicking the Dwell checkbox. When the user specified edit box is selected, the value, in milliseconds, allows the sweep to be slowed down by specifying a dwell (delay) value that is used by each point before data collection commences. A value from 0 to 999 may be entered.

Source Parameters Toolbar

on off
Level
_evel 1.00000
<
66B 1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-
1
16 18 110
4
DC Source 0.0
0.0
<
Fine
0.00

Output

If On then the AC output is set by the level established in the Level edit box. If Off then the AC output from the source is set to zero regardless of source Level setting. The DC source offset is not affected. The output must be off when measuring signals generated from an external source.

Level

The source output level entry ranges from 1.25 mV to 1.77 V RMS. There are 64 discrete levels available in 1 dB increments. The level may be typed in directly or increased / decreased in 6 dB and 1 dB steps. Note: When the level is typed in directly use the Carriage Return (Enter) or Tab key to enter the new value. When using the inc / dec buttons the source level will be updated automatically.

DC Offset

The Source entry has a range of +/-10 Volts DC with a resolution of 0.1 Volts DC. The Fine entry has a range of +/-0.128 Volts DC with a resolution of 0.002 Volts (two millivolts) DC. It is advised to first set the source followed by the fine adjust. The new DC offset will be entered after hitting the Carriage Return (Enter) or Tab key.

Receiver Parameters Toolbar

AC DC x1 x10 Preamp Auto Ŀ Bandviidth 1 KHz

Ac DC Coupling

can only be used for sweep frequencies >= 10 Hz. If DC coupling is selected than automatic DC offset tracking is employed for inputs up to \pm 10 VDC. If AC is selected the analyzer uses its internal coupling capacitors. AC coupling

x1 x10 Atter

have an erroneous result of 20 dB. A and channel B probes must have the same setting or else the measurement will tion must reflect the actual input channel probe settings. Note that both channel In order for the analyzer to use the proper frequency correction array the selec-

Normally Auto is selected This selection allows the automatic preamp gain selection to be overridden

bandwidth that gives a trace with acceptable noise levels floor will change approximately 10 dB with each setting. Choose the highest lower, or narrower the IF bandwidth the better the noise immunity. The noise The higher, or wider, the IF bandwidth the faster the sweep will take place. The

System Calibration

Overview

least 30 minutes last calibration. Perform system calibration after the unit has warmed up for at tion has changed or the ambient operating temperature has changed since the tion should be performed periodically and whenever the input probes configura-To obtain accurate measurements the system must be calibrated. System calibra-

current graph display mode. to change the current calibration setup. To load an existing calibration file, click performs the calibration procedure and saves the new calibration data to a file the Browse button and then choose the file to load. Clicking the Create button Use the Calibration File Maintenance dialog (select calibration in the Files menu) The newly created calibration file is automatically selected and used by the

System calibration is accomplished by performing the four calibration Create procedures in the following order

- [1] Source DC Null Calibration
- [2] Receiver DC Null Calibration
- [3] Frequency Response Calibration
- [4] Absolute Magnitude Calibration

required for successful system calibration The calibration files are displayed within the dialog box in the top down order

calibration files are provided by AP Instruments, named default.xxx. It is recom mode is selected the calibration files last used in that mode are loaded. Defaul within a graph display mode are local to that mode, whenever a graph display are saved with user defined names, this allows calibration files to be maintained mended that these cal files are not deleted or overwritten. for various test setup configurations. Be aware that the calibration files selected After every calibration procedure the cal data is saved to a file. Calibration files

will first try to load the default file (default.xxx). If the default file could not be found it will be necessary to select (Browse) an existing file or create a new one cation as to which file type[s] could not be loaded. When this occurs, the system In the event that a calibration file cannot be found the system will provide notifi-

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Source DC Null Calibration

ing temperature changed since the last calibration. The calibration should be performed periodically especially if the ambient operat-The network analyzer utilizes correction arrays to correct for source DC offsets

Source DC Null Calibration Procedure

- If the system is running, stop sweep activity
- Select Calibration from the File menu.
- Click the Create button to the right of the Source DC Null Cal Filename
- When prompted, connect Channel A to ground, This can be accom-Click OK when ready. [Probe REF calibration will take approx 1 sec., plished by switching the Channel A probe to the REF position.
- 5 When prompted, connect Channel A to the Source Out of the unit. Verify the Channel A probe is in the x1 position.
- [6] When calibration is complete save as a new file or overwrite an existing calibration file. Click OK when ready. [x1 probe calibration will take approx 20 sec.]

Receiver DC Null Calibration

operating temperature changed since the last calibration. calibration procedure should be performed periodically, especially if the ambient correction arrays, are then used to correct for the analyzer's receiver DC offsets cannot be used. For external sources another method, receiver input offset built into the analyzer) the automatic receiver input offset calibration process When measuring signals that are derived from an external source (not the source These arrays are created by the receiver DC null calibration procedure. The

Receiver DC Null Calibration Procedure

- If the system is running, stop sweep activity
- Select Calibration from the File menu.
- Click the Create button to the right of the Receiver DC Null Cal Filename
- receiver isolation inputs. Removing the probe BNC connectors from the unit will guarantee When prompted, remove any signal from the Channel A and Channel B

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[5] When calibration is complete save as a new file or overwrite an existing calibration file. Click OK when ready. IReceiver calibration will take approx 10 sec.]

Frequency Response Calibration

ments unless the x10 calibration is performed. Note: the x10 position of the Receiver Atten will not provide correct measure formed periodically and whenever the input probes configuration is changed. DC) and preamp selections. A frequency response calibration should be perpensate for all combinations of probe (x1 or x10), band, coupling mode (AC or The network analyzer utilizes frequency correction arrays to automatically com

ground leads etc. The frequency calibration is performed at one power level only so any non-linearities in the receiver path, including probes, will introduce small variation at high frequencies than coax with BNC interconnects due to long takes place at approximately 0.396 V rms. Test probes will show a greater band switch occurs at 11 kHz while the receiver preamp switching threshold probe, band, coupling mode and preamp selections must be exercised. The menu probe selection. Optionally, to test all of the arrays all combinations of frequency range. Make sure that the probes switch settings reflect the receiver dB magnitude and 0 degrees phase, within the specified accuracy, across the the source and receiver probes together. The analyzer should give a reading of 0 To check the validity of the frequency response correction arrays simply connect

Frequency Response Calibration Procedure

- If the system is running, stop sweep activity
- <u>3</u> <u>2</u> <u>3</u> Select Calibration from the File menu
- Click the Create button to the right of the Frequency Response Cal
- [4] Channel B inputs. Verify the probes are in the x1 position When prompted, connect the Source Out to both the Channel A and
- probes in the x1 position only, or in custom fixture applications the x10select Yes to continue with x10 probe calibration. Otherwise, when using If measurements will be made with the probes in the x10 position then Click OK when ready. [x1 probe calibration will take approx 11/2 min.]

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Skip step [6] when selecting No. calibration may be bypassed by selecting No. If the supplied probes are being used it is recommended that the x10 calibration be performed.

- [6] When prompted, Verify the probes are in the x10 position Click OK when ready. [x10 probe calibration will take approx 1½ min.]
- [calibration file. When calibration is complete save as a new file or overwrite an existing

Absolute Magnitude Calibration

sured single point, and (3) full spectrum calibrations. Each level yields greater mately compensated for by fixed correction coefficients leaving a DC gain error array contains gain and roll-off error terms. The roll-off error term is approxivalue has both a DC gain error and high frequency roll-off error the calibration depends on the nominal value of the source for its accuracy. Since this nominal default value. This first procedure requires no external measuring equipment and calibration is performed by selecting the single point calibration and using the which the resources are available to perform the calibration. The first level of accuracy in absolute magnitude measurements. Choose the highest level in There are three levels of calibration available, (1) default single point, (2) mea

measuring 100 Hz, 1.0 VAC RMS with millivolt resolution. The voltmeter should Measured Single Point Calibration (Correcting for the DC Gain Error Term specific cabling configuration. For the x1 cable use a BNC tee at the source with measured value. Enter the value directly in volts AC RMS. The voltmeter is then model 102 analyzer's source when the program prompts the operator for the measurement frequency of 100 Hz. The AC voltmeter is connected up to the have a bandwidth of 1 KHz or more to ensure an accurate response at the required for this procedure needs to have an AC RMS voltage range capable of To correct for the DC gain error use the second level calibration. The voltmeter x10 cable (probe) configuration use a five foot BNC to minigrabber at the source will give the absolute voltage referenced at the analyzer's BNC inputs. For the proximated roll-off error term it is required to make this connection using a channels A and B. To generate the correct calibration coefficients for the apremoved and the model 102 analyzer's source is connected to the analyzer's with 10-to-1 probes connecting channels A and B. This setup for the x10 posi-12 inch BNC cables connecting channels A and B. This setup for the x1 position

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Full Spectrum Calibration (Correcting for the Roll-Off Error Term) tion will give the absolute voltage referenced at the x10 probe inputs

along with the analyzer's input channels A and B using x1 cable or x10 probes. the correction array has been completed and stored to a file. the value directly in volts RMS. Keep the measuring instrument connected unti the measured values at the sixteen frequency points (100Hz, 1-15MHz). Enter with a 50 Ohm through-line adapter. The program will prompt the operator for instrument's input is a high impedance input, then the input must be terminated input is close to the analyzer's inputs (or x10 probe inputs). If the measuring The connection should be arranged so that the tap to the measuring instrument's Connect the model 102 analyzer's source and the measuring instrument's input A spectrum analyzer, or a digital oscilloscope with FFT measurement capability. pieces of equipment capable of covering the 100 Hz to 15MHz range is required: procedure, called full spectrum calibration, is available. One of the following To accurately correct for the roll-off error term (and DC gain error term) another

Absolute Magnitude Calibration Procedure

- If the system is running, stop sweep activity
- Ξ Ξ Select Calibration from the File menu.
- Click the Create button to the right of the Absolute Magnitude Cal
- For the single point calibration, continue with the Single Point Calibration Select the single point or full spectrum calibration

Procedure.

For the spectrum calibration, continue with the Full Spectrum Calibration

Single Point Calibration Procedure

voltmeter is not available. Click OK when ready. value. The default value may be used to perform the calibration when a When prompted, measure the Source Out voltage (Vrms) and enter the

<u>[</u>

[a]

will take approximately one minute to complete) are in the x1 position for the x1 cal. Click OK when ready. { Calibration (measured single point calibration). When using probes, verify that they Channel B inputs. Review recommendations for cable connections When prompted, connect the Source Out to both the Channel A and

- \Box skipped when selecting No. probes in the x1 position only, or in custom fixture applications the x10select Yes to continue with x10 probe calibration. Otherwise, when using If measurements will be made with the probes in the x10 position then calibration may be bypassed by selecting No. Steps [d] and [e] will be
- ₫ voltmeter is not available. Click OK when ready. When prompted, measure the Source Out voltage (Vrms) and enter the value. The default value may be used to perform the calibration when a
- <u>[e]</u> when ready. [Calibration will take approximately one minute to com-When prompted, verify the probes are in the x10 position and the Source Out to is connected both the Channel A and Channel B probes. Click Ok
- Ŧ calibration file When calibration is complete save as a new file or overwrite an existing

Full Spectrum Calibration Procedure

- a probes, verity that they are in the x1 position for the x1 cal. Click OK Channel B inputs and to the spectrum analyzer. Review recommenda tions for cable connections (full spectrum calibration). When using When prompted, connect the Source Out to both the Channel A and wnen ready
- ₫ each at megahertz from 1MHz to 15MHz. Click OK to register each enter the value. Sixteen measurements will be required, at 100Hz and Measure the Source Out voltage (Vrms) using the spectrum analyzer and value and continue to the next measurement.
- [C] skipped when selecting No. calibration may be bypassed by selecting No. Steps [d] and [e] will be probes in the x1 position only, or in custom fixture applications the x10select Yes to continue with x10 probe calibration. Otherwise, when using If measurements will be made with the probes in the x10 position then Calibration will proceed when the last measurement has been entered
- <u>[e]</u> [<u>d</u>] when ready When prompted, Verify the probes are in the x10 position. Click OK
- when the last measurement has been entered value and continue to the next measurement. Calibration will proceed each at megahertz from 1MHz to 15MHz. Click OK to register each enter the value. Sixteen measurements will be required, at 100Hz and Measure the Source Out voltage (Vrms) using the spectrum analyzer and
- When calibration is complete save as a new file or overwrite an existing

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Dynamic Data Exchange

Understanding Dynamic Data Exchange (DDE)

What is DDE?

and server. A DDE link is established by the client. provide data to other applications through the windows dynamic data exchange to communicate with one another. A DDE server is an application which can through a DDE link. A DDE link is a communications channel between a client protocol. A DDE client is an application receiving data from a DDE server Dynamic Data Exchange (DDE) is a protocol which allows windows applications

request (link) each time data is needed sponse to a client request, then the link is terminated. The client must initiate a exits. A DDE cold link is a DDE link in which data is sent by the server in rewill continue until the link is terminated by the client, or the server application not required to initiate any other DDE communications. The server notifications once established, the server will notify the client as data changes. The client is link is most common (and most useful). A DDE Hot link is a DDE link where, requested information. There are two types of DDE links, Hot and Cold, The hot information, Once this link is made the server will update the client with the A DDE server can provide data to one or more DDE clients through DDE links. Clients establish a communication (link) with a server in the form of a request for

How is a DDE link established?

client application software owners manual for specific information needs to know what services, topics and items the server provides. Each client service having several topics and each topic handling several items. A client name and Item name. In general, a server can have many services with each tion which describe the needed data. This information is the Service name, Topic A client will begin requesting data by sending the server three pieces of informahas its own technique (syntax) for requesting this information, refer to the DDE

A Client executes commands!

For the most part DDE is used as a means for one application (client) to receive real-time data from another application (server). In some cases the server allows the client to execute a command. This is accomplished as with a link, The client will send a service, topic and item for the command the server is to execute. After receiving the request the server will execute the command. Also, as with links, the client needs to be aware of what services, topics and items are available.

What about NA Windows Connectivity?

NA Windows Connectivity is a DDE server with the following capabilities:

nks:

Service - NAWINCON

Topic - NA_DATA

Items - POINTS, FLACS, FREQ, MAC, PHASE, ABSMACA,

ABSMACB

Executes:

Service - NAWINCON

Topic - NA_SWEEP

Items - [START], [STOP], [RESET]

Service - NAWINCON

Topic - NA_LOAD ltems - [DEFAULT], [SetupFilename.set]

Note: The brackets [] are required for execute items.

Item Definitions

POINTS

Returns: The number of points entered in the points edit box in the sweep parameters window. Or, when using a frequency points list file, the

number of frequency points in the file.

Format: A single number. (Integer as text).

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FLAGS

Returns: The settings in the Format Phase dialog box

Format: A single number. (Integer as text). The least significant bit holds the

phase group information:

1 - 0 to 360°

0 - +/- 180°

FREQ

Returns: The frequency value for all points of a sweep

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS.

MAC

Returns: The magnitude (B/A) value for all points of a sweep

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D

0x0A). There are as many numbers as the value of POINTS.

PHASE

Returns: The phase (B/A) value for all points of a sweep

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D)

0x0A). There are as many numbers as the value of POINTS. The values will be formatted 0->360 or +/- 180 as selected in the Format

Data dialog box.

ABSMACA

Returns: The absolute magnitude of input channel A for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D

0x0A). There are as many numbers as the value of POINTS.

ABSMACB

Returns: The absolute magnitude of input channel B for all points of a sweep.

Format: A series of numbers (doubles as text) separated by a <CR/LF> (0x0D 0x0A). There are as many numbers as the value of POINTS.

START

Executes the Start Sweep function of NA Windows Connectivity.

[STOP]

Executes the Stop Sweep function of NA Windows Connectivity.

RESET

Executes the Reset Sweep function of NA Windows Connectivity.

[DEFAULT]

Executes the File | Default Setup menu option of NA Windows Connectivity.

[SetupFilename.set]

Allows loading a setup file through DDE. Executes the File | Open Setup menu option with SetupFilename.set as the setup file to load. SetupFilename.set is any valid setup file which has been previously saved.

Using DDE in Microsoft Excel

It is recommended the user be familiar with Excel and Excel Visual Basic programming. Also knowledge of NA Windows Connectivity's Services, Topics & Items is essential.

For use with NA Windows Connectivity there are three types of DDE links which are useful. These are:

- (1) Hot data links for single values. Used to receive the Network Analyzer frequency points and data format flags.
- (2) Hot data links for arrays of numbers. Used to receive the sweep arrays for Frequency, Magnitude and Phase measurements.
- (3) Execute links to send commands to NA Windows Connectivity (i.e. Start sweep, stop sweep, load default settings, etc...).

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Hot links to data items of single values

Excel provides a simple method of establishing a data hot link. To start a hot link, enter into the cell:

=Service | Topic! Item

Select the cell to contain the data then enter an equal sign (=) followed by the name of the Service (the service is always NAWINCON for NA Windows Connectivity), a vertical bar (may be found above the backslash), the Topic name (the topic is always NA_DATA for NA Windows Connectivity), an exclamation point (!), then finally the Item name (either POINTS or FLACS). Since NA Windows Connectivity supports only two single value data links, the links may be established as:

=NAWINCON|NA_DATA!POINTS

and

=NAWINCON|NA_DATAIFLAGS

Once the cell formula has been entered the DDE link is established and the 'conversation' will begin. Note: The DDE server must be running or in the PATH to start the link.

Hot links to data items of arrays

This is similar to single value hot links but there are two important differences. First, multiple cells must be selected to hold the data (select as many cells as the number of sweep points). Multiple cells are selected by first selecting a single cell then dragging the bottom-right corner of the cell down the spreadsheet. While the cells are selected type in the formula as above. The five data arrays available for hot link transfer are:

- =NAWINCON NA_DATA!FREQ
- =NAWINCON NA_DATAIMAG
- =NAWINCON NA_DATA!PHASE
- =NAWINCON NA_DATA!ABSMAGA
- =NAWINCON|NA_DATA!ABSMAGB

Second, after typing in one of the above formulas, enter the array formula by pressing CTRL+SHIFT+ENTER (hold the CTRL & SHIFT keys then press ENTER).

Execute links

Several NA Windows Connectivity commands are available through DDE to help automate data collection and analysis. Excel performs cold link connections by opening a *DDE channel*. Commands are sent using this open channel and the channel is closed when no longer needed. The procedures to open, send commands through, and close channels are executed in Visual Basic routines. To open a DDE channel use the DDEInitiate command as follows:

ChannelID = DDEInitiate("Service", "Topic")

DDEInitiate returns a channel ID, this ID is used to execute commands of the Service-Topic used as arguments of the DDEInitiate. To send a command use the DDEExecute command:

DDEExecute ChannelID, "Item"

And when finished with the channel close it using the DDETerminate command:

DDETerminate(ChannellD)

DDETerminate(ChannelID)

There are various ways to manage ChannellD's as defined by the Excel application. Below are two recommendations with examples.

First, If the channel is to be used infrequently (possibly only once) then place all DDE transactions in a single function. As an example, assume the parameter configuration setup file BANDPASS.SET is required whenever the spreadsheet is used.

Also it is assumed that NA Windows Connectivity has been installed using the default path location. The function Auto_Open() is defined as automatically executing whenever the spreadsheet begins. The subroutine below uses this function to load the setup file.

Sub Auto_Open()

NA_LoadChannel = DDEInitiate("NAWINCON", "NA_LOAD")
DDEExecute NA_LoadChannel, "[C:\NAWINCON\BANDPASS.SET]"
DDEFerminate(NA_LoadChannel)

Fnd Silh

Next, If the channel is to be used frequently while the spreadsheet is active then it is easier to break up the DDE commands. In this case be sure to define the DDE Channel <u>outside</u> any function so it will have global variable scope. As an

example, assume a macro is required that will start a sweep when called. This macro, ExecSweepStart(), may be called many times therefore the following programming methodology is used.

Dim NA_SweepChannel

Sub Auto_Open()

: other initialization

NA_SweepChannel = DDEInitiate("NAWINCON","NA_SWEEP")
End Sub

Sub Auto_Close()

DDETerminate(NA_SweepChannel)

: other exit procedures

End Sub

Sub ExecSweepStart()

DDEExecute NA_SweepChannel, "[START]"

End Sub

As with Auto_Open(), Auto_Close() is defined in Excel to execute whenever the spreadsheet terminates. The spreadsheet provided with NA Windows Connectivity NALINK.XLS provides many examples of DDE communication and processing.

Example Excel Spreadsheets

Included are three example Excel spreadsheets. Feel free to use them as is, or modify for your own use.

NALINK.XLS

Nalink.xls is an excel spreadsheet for use with NA Windows Connectivity. Nalink becomes a DDE client of NA Windows Connectivity to view magnitude and phase data (graphically & numerically. Nalink will be most useful when in a video

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mode of 800x600 with Excel maximized, the graphs are designed to fit without scrolling.

Important: Ensure NA Windows Connectivity is running prior to starting this spreadsheet. Nalink.xls will not be able to establish the DDE links otherwise. Nalink is configured as four pages (Data, Mag & Phase, Mag, and Phase) with buttons on each page to move to any other. Each page also has a button called "NA Controls", this brings NA Windows Connectivity forward for parameter entry. Click the Excel spreadsheet to place NA Windows Connectivity in back again. The Data page has buttons to set (and clear) the current data as a master waveform. The graphs display the master waveform along with the current data. The graph pages contain buttons to start and stop a sweep, and set NA Windows Connectivity to the default setup configuration.

Most of the DDE Data & Execute links of NA Windows Connectivity are used in this spreadsheet. All functions and macros (subroutines) are defined on the 'functions' tab.

ABSLINK.XLS

Abslink.xls is the functional equivalent of Nalink.xls but displays the absolute magnitudes of channel A & B instead of Mag & Phase.

Important: Ensure NA Windows Connectivity is running prior to starting this spreadsheet. Nalink.xls will not be able to establish the DDE links otherwise.

CPLXIMP.XLS

Cplximp.xls provides complex impedance and equivalent network component calculations.

Application Notes

Introduction to Analog Network Measurements

Network analysis and network measurements determine the most fundamental properties of a given network. These properties include the frequency response transfer function, input/output impedance and group delay all over a given frequency range. In many electronic applications, including filters, amplifiers and systems with feedback the most important characteristic is the frequency response of that network, circuit or system. The frequency response gives the magnitude (gain or attenuation) and phase, as a function of frequency, between two desired points in the system under test. The frequency response is measured directly by a network analyzer for voltage-voltage transfer functions. High frequency power transfer functions are measured by the addition of a power splitter and through-line terminations. Impedance can be calculated using a known reference resistor in series with the unknown network. Croup delay can be derived from the phase data since it is the negative derivative of phase with respect to frequency.

In the case of filters the two quantities of interest are typically the stopband attenuation and the passband insertion loss along with possibly the group delay characteristic in the passband. With amplifiers the main quantity of interest is gain "flatness" over frequency in which case the 3 dB gain rolloff point defines the amplifiers bandwidth. With feedback systems, either electrical or electromechanical, the open and closed loop frequency response characterize the system. Feedback systems can exhibit unwanted oscillations, i.e. instabilities, unless the open loop response is evaluated, and appropriately compensated for, to ensure stability.

The frequency response function of an electrical network is defined as the sinusoidal output response divided by the sinusoidal input stimulus. The input and output can be voltage or current depending of the desired transfer function. Note that the frequency response is a *ratioed* quantity of output to input, and that the input and output are described by complex numbers or phasors. The frequency response, at each frequency point of interest, is then given by a complex number, or phasor. The phasor can be fully described by its magnitude and

phase components. It is these quantities, the magnitude and phase of the input and output that are measured and ratioed by the network analyzer to obtain the frequency response.

The B/A ratioed measurement described above is equivalent to subtracting the input signal from the output signal when each quantity is in logarithmic form. In the model 102B network analyzer the network's input signal is, by convention, measured by channel A and the output signal is measured by channel B. The expression B/A then describes the resulting frequency response transfer function.

Basic Measurement Procedures

The optimum network analyzer measurement setup is, as expected, highly dependent on the circuit under test. The frequency range of interest, circuit gain, circuit impedance at the probe points and DC voltage levels are among the factors affecting the measurement setup. Passive circuits are generally easier to measure than active circuits because they have low noise levels, don't usually have special bias voltage requirements and are typically insensitive to source drive levels. Active circuits, on the other hand, may have the properties mentioned above that make measuring them in a linear mode of operation more challenging. It is important to have a good idea of what the measurement results should be before they are taken. The real value of network measurements is in finding the incalculable and the miscalculated frequency response.

Users that are new to network measurements should become familiar with the analyzer's operation by first measuring a simple passive network before advancing to measuring, for example, the loop gain of a high gain feedback circuit.

General Measurement Procedure

Using the control panel set the network analyzer parameters to the following:

- [1] In the FILE menu select Default Setup or load a specific configuration previously defined and saved using the Open Setup menu selection. This will establish a set of system parameters for general use. Specific requirements are met by using the appropriate control panel button or menu
- [2] Set the desired frequency coverage by using the START and STOP or CENTER and SPAN control panel buttons located in the SWEEP subpanel. If the start frequency is less than 10 Hz then DC coupling will have to be selected in the RECEIVER subpanel.
- [3] If desired set the graph title using the OPTIONS | Title menu selection.
- [4] Decide on what stage(s) in the circuit the transfer function is to be measured. Locate the input node and output node of this network.

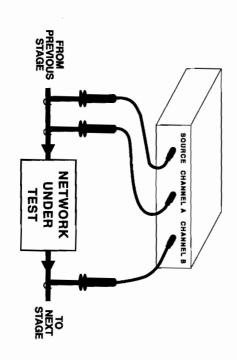
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[5] As depicted below, connect up the source probe and the channel A probe to the network's input node. Connect up the channel B probe to the network's output node. If the output impedance of the stage preceding the network under test is less than approximately 50 ohms then an isolation resistor may be needed to provide a high enough source drive level. Make sure that the x1, x10 switch on both channel A and B probes are in the same position, typically x1, and this setting corresponds to the attenuation entered in the RECEIVER subpanel. See the application note on high frequency measurements.

If not in a continuous sweep mode then select this mode in the SWEEP subpanel. Increase the source drive level from its minimum level until the graphics display shows a noise free plot. If the plot is not visible or only partly visible actuate the Autoscale function from the toolbar. Bandwidth can also be adjusted so as to optimize trace noise or sweep time. Take care not to increase the source drive level to a point such that the network under test is no longer operating in a linear mode of operation as this can give erroneous results.

[6]

Basic Measurement Setup



High Frequency Measurements

At frequencies higher than a few hundred kilohertz two important issues arise in network measurements. The first is that of isolation between a network's input and output nodes. The analyzer has a minimum dynamic range of 100 dB which can be compromised by coupling paths within the network under test or in the probe connections themselves. The source of this isolation problem can be either 1) conducted through "common mode impedances" and/or 2) radiated, with radiated coupling typically increasing with frequency. Basic RF layout and design practices reduce or eliminate this problem. It is recommended that coaxial cables with BNC interconnects be used above one megahertz.

The second issue is that of probe loading effects. For higher frequency measurements on high impedance circuits determine (very approximately) if the 80 pf capacitance of the probe tip in the x1 position on the output node will influence the measurement. The output node should have an impedance commensurate with the desired measurement accuracy. For example at 1MHz a capacitance of 80 pf has an impedance of 2K ohms and the node under test should then have an impedance of 200 ohms or less, at 1 MHz. This will give errors of less than 0.05 dB magnitude and 6 degrees phase. Although inconvenient, the effect of the probe shunt capacitance can be factored out knowing the actual output impedance of the circuit. The x10 position will reduce the probe capacitance to under 15 pf although the dynamic range of the instrument will typically be lowered by 20 dB in this setting. Note that BOTH channel A AND channel B probes must have the SAME setting or else the measurement will have an erroneous result of 20 dB. It is also important that the probe attenuation be entered into the RE-CEIVER window Atten selection for the automatic frequency correction to be valid.

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Circuits with Nonzero DC Voltage Levels at the Input / Output Node

If the circuit's selected input node, also the network analyzer's source connection and channel A connection, has a nonzero DC voltage it will be necessary use one of the following techniques: 1) DC offset the source (+/- 10 VDC max) to match the circuit's offset using the DC OFFSET entry in the SOURCE window or 2) AC couple the source to the circuit using a capacitor or transformer. If method 2 is used consideration will have to be given to the difficulty in obtaining a sufficiently low driving impedance at low frequencies with a reasonably sized coupling capacitor. In the case of a transformer low and high frequency response needs to be considered. The coupling method does not need to have a flat response since ratioed measurements cancel source flatness deviations. In both techniques the input channels must also be either: 1) AC coupled using the network analyzer's internal coupling capacitor (>=10Hz only), or 2) DC coupled which will enable the automatic DC offset tracking up to a maximum of +/- 10 VDC. To allow sufficient voltage "headroom" for large amplitude signals the maximum DC offset should be +/- 7.5 VDC.

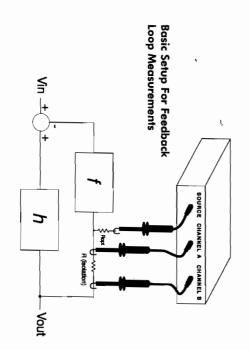
Measuring Circuits with High Common Mode Voltages

For frequency response measurements on circuits that have large voltage offsets (>10 VDC) from ground it is necessary to couple the source to the circuit under test using a signal injection transformer such as the HP model 35282A or another suitable transformer covering the frequency range of interest. Using 10-to-1 probes for the receiver's input channels will increase the maximum input voltage to 200 Volts. For high voltages the receiver channels can also be either transformer coupled, connected using active differential probes, or connected using an isolation amplifier. Running a frequency calibration with any of the aforementioned connection schemes, with the probes in place, will remove (i.e. normalize) the frequency response of the probes.

Measuring Feedback Loop Frequency Response

In feedback circuits it is necessary to measure the gain and phase for the complete path around some chosen loop, i.e. the open loop gain and phase. If the network analyzer is connected such that the source and channel A are connected to the desired "beginning" point in the loop and channel B is connected to the desired "end" point in the loop the gain measured is the desired loop gain and the phase measured is the phase change around the loop. In the case of negative feedback, the phase change includes a 180 degree phase shift when the feedback signal is inverted in the loop.

The network analyzer display shows a +-180 degree phase range so the inversion in the feedback loop will cause any additional phase shifts beyond -180 degrees to "wrap around" and appear as a phase of +180 - (additional phase shifts). In a typical negative feedback circuit with one pole (i.e. 20 dB/decade rolloff) the phase would start off at +180 degrees and, at the pole frequency, show +135 degrees. The phase reading can then be directly interpreted as "phase margin" at the frequency where the loop gain magnitude is equal to one (0 dB).



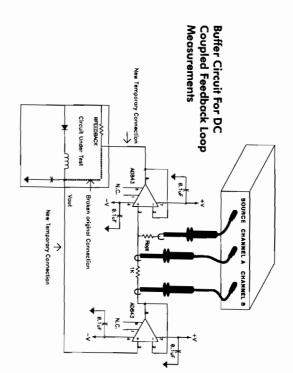
In most cases to make a loop gain measurement the feedback loop must be left closed due to high DC gain or bias conditions. These conditions would force the circuit into a nonlinear area of operation if the loop was opened making a valid measurement impossible. If the node at the source connection has a nonzero voltage then the source will have to be DC offset to match the node voltage or AC coupled using a capacitor or transformer. The resistor Ropt can be used to prevent circuit loading due to small differences in source and circuit voltages. For high frequency loop gain measurements the source probe capacitance as well as the input channel probe capacitance can have a destabilizing effect on the circuit see the high frequency measurement note above. The source probe capacitance effect can be reduced by using a series resistor between the source and the circuit's selected node. Use a resistor as large as needed to maintain stability. The source drive level can be increased to the level required to obtain a noise free trace.

Two measurement methods are detailed below. The first is a DC coupled technique which has the advantages of a DC to 15 MHz frequency coverage. The disadvantage of this technique is that its implementation may require the use of a buffer amplifier. The second, AC coupled, technique is simpler in that it only requires a resistor and a transformer to implement. The disadvantage of this technique is that it is frequency limited by the bandwidth of the transformer used.

DC Coupled, Buffer Amplifier Method

Unless the feedback loop under test has a buffer stage with high input impedance and low output impedance it may be necessary to temporarily add such a stage to maintain the existing feedback loop characteristics and make a valid measurement. The diagram below shows the placement of such a temporary buffer and the network analyzer connections for a feedback loop frequency response measurement. The buffer circuit below, with the 35 MHz bandwidth op-amps, adds approximately 3 degrees of phase shift at 1 MHz to the measurement. Lower speed op-amps can be used for lower frequencies, if desired. The circuit shown assumes Zout @ Vout is much lower than RFEEDBACK over the frequencies of interest. If this is not the case then to obtain the actual loop gain response it may be necessary to terminate the Vout node with an impedance equivalent to RFEEDBACK and to add a series impedance to RFEEDBACK equal to Zout.

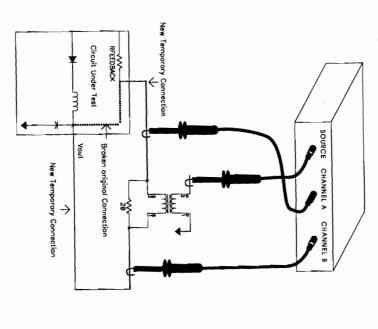
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AC Coupled, Transformer Method

The secondary of a transformer is used in this technique to develop a drive voltage across a small resistor, typically 10 to 50 Ohms. This resistor is typically placed in series with the loop's feedback resistor as shown in the diagram below. The transformer's frequency response does not have to be flat over the measurement range but does need to provide an adequate drive level over the measurement range to ensure a good signal to noise ratio.

Configuration For Transformer Coupled Feedback Loop Measurements:

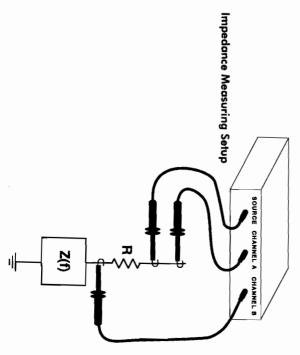


Measuring Complex Impedance

To measure the input or output impedance of a network the analyzer is connected to a known reference resistor, **R**, that is in series with the network. The source output and channel A are connected to one side of **R** and the other side of **R** is connected to channel B and the network under test as depicted below. For best accuracy the resistor **R** is chosen such that its impedance is within a factor of 5 or so of the expected impedance of the network under test, at the frequency of interest. The impedance calculations derived below are done automatically by the software when the Complex Impedance option is chosen

Let the transfer function measured by the analyzer be $\mathbf{H}(f)$, the unknown complex impedance, $\mathbf{Z}(f) = \mathbf{x} + \mathbf{j} \cdot \mathbf{y}$, is then given by: $\mathbf{Z}(f) = \mathbf{R} \cdot \mathbf{H}(f)/(1 \cdot \mathbf{H}(f))$. This result is derived using the generalized voltage divider formula with the substitution of $\mathbf{VB} = \mathbf{H} \cdot \mathbf{VA}$. First the magnitude of $\mathbf{H}(f)$ is converted from dB's to linear form by dividing by 20 and taking the antilog (base 10). The phase is used directly as read

within the Graph menu.

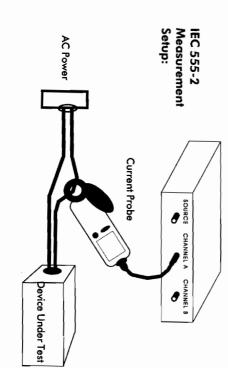


equivalent reactance of the network under test. A capacitive reactance will have quency in Hz. equivalent inductance given by $L = y/(2 \cdot pi \cdot f)$ where f is the measurement frea negative imaginary part, while an inductive reactance will have a positive ing the equivalent series resistance, and a imaginary part, y, representing the with the phase now represents **H**(t) in polar form, and is then converted to imaginary part. The equivalent capacitance is given by $C = -1/(2 \cdot pi \cdot f \cdot y)$ and the number is the impedance in ohms and will typically have a real part, x, represent rectangular form and substituted into the formula above. The resulting complex from the analyzer taking care to include the sign. The converted magnitude along

IEC 555-2 Measurements

as 50 Hz or 60 Hz. using an external current transducer connected to channel A. The limits as set graphs a plot of the first forty harmonics of the power line current as measured able when the IEC 555-2 option is chosen within the Graph menu. This mode A display and measurement mode for IEC 555-2 precompliance testing is avail. by the user before this test is undertaken. A copy of this standard is available forth by the IEC 555-2 document, section 4.1 table 1, are plotted with an x. It is harmonics, is plotted as a bar chart. The line current frequency is user selectable through ANSI, Phone (212) 642-4900. The measured data, the first forty current highly recommended that the IEC 555-2 standard be obtained and understood

meets the above requirements is the PR-30 available from LEM USA, Phone when connected to measure line current. One such current transducer that safety isolated and meets the SELV (Safety Exposed Low Voltage) requirements 50 Hz to 2.5 KHz. Note that the current transducer must have an output that is channel A, whose sensitivity in Volts per Amp is entered as an input parameter. (414)-353-0711. The current transducer frequency response bandwidth is required to be flat from The current is measured using an external current transducer, connected to



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Power Transmission/Reflection Measurements

ships given below. analyzer has the capability to measure transmission (S21 or S12) as well as the reflection measurements, a directional coupler. The model 102B network under test. This is accomplished by using a power splitter and, in the case of to determine the actual power transmitted through or reflected from the network is measured by the analyzer. Also the measurement configuration must be able ance (typically 50 or 75 ohms). This will convert the power into a voltage which need to be terminated, using feedthrough terminations, to the desired impedance inputs. To measure power transfer functions the network analyzer inputs configuration, measures voltage/voltage transfer functions since it has high imped are not necessarily the same. The model 102B network analyzer, in its most basic network due to impedance mismatches the voltage and power transfer functions functions. Because power can be reflected as well as transmitted through a eters of interest involve not voltage transfer functions but rather power transfer return loss measurement's magnitude and phase information using the relationthe reflection coefficient, VSWR and impedance can be calculated from the return loss of a reflection measurement directly. The derived quantities including In applications such as passive filters and circuits for communications the param

Reflection coefficient magnitude = 10 ^ (-return loss/20) where the return loss is expressed as a positive quantity in dB. The reflection coefficient magnitude is between 0 and 1.

Reflection coefficient phase = the phase measured at the return loss measurement.

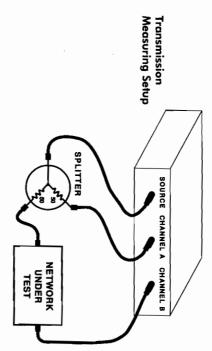
VSWR = (1 + reflection coefficient magnitude)/(1 - reflection coefficient magnitude).

Impedance = Characteristic impedance (i.e. 50 Ohms) *(1 + reflection coefficient)/(1 - reflection coefficient)

Transmission Measurements

In the case of transmission measurements the power incident to the network under test can be determined by sampling the incident source power using a power splitter and making a ratioed measurement of the output power to input power. As shown in the drawing (below) the sampled incident power is mea-

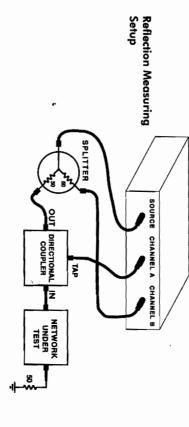
sured by channel A while the transmitted power is measured by channel B. Note that the input channels A and B must be terminated to the characteristic impedance of the network under test using feedthrough terminations. A frequency calibration can be performed with the power splitter in place and a through line substituted for the network under test for enhanced accuracy. The power splitter can be a simple resistive splitter shown below which will result in a 6 dB power loss from the source to the network under test. A low loss transformer coupled splitter such as a Mini-Circuits model ZSC-2-2 can also be used.



Reflection or Return Loss Measurements

With reflection measurements the power reflected from the network under test back toward the source is the quantity of interest. The reflected power is measured by a directional coupler such as a Mini-Circuits model ZDC-15-6. The directional coupler has a tap which represents a portion (i.e. -15 dB) of the reflected power. A return loss measurement can be made by taking a ratioed measurement of the incident power to the reflected power. The incident source power is sampled using a power splitter. As shown in the drawing (below) the sampled incident power is measured by channel B while the reflected power, as sampled from the coupler tap, is measured by channel A. This ratio is taken to

keep return loss a positive quantity. Note that the directional coupler's output port is connected to the power splitter while the coupler's input port is connected to the network under test. This is because it is the reflected power from the test network that enters the coupler's input port. Note that the input channels A and B must be terminated to the characteristic impedance of the network under test using feedthrough terminations. A frequency response calibration must be performed with the power splitter and directional coupler in place using a short substituted for the network under test. The short will give a theoretical return loss of 0 dB with a phase shift of 180 degrees and gives the reference point by which the return loss is measured. The -15 dB reflected power coupling tap of the directional coupler is calibrated out by the frequency response calibration procedure.



APPENDIX A

Theory of Operation

The Model 102B Network Analyzer System is comprised of a host PC, a DSP board and a Source/Receiver unit. The host PC provides the operator I/O, file storage and data post-processing. The DSP Board provides the real time data preprocessing and power supply for the Source/Receiver unit. The Source/Receiver unit contains the frequency source output and the two input, or receiver

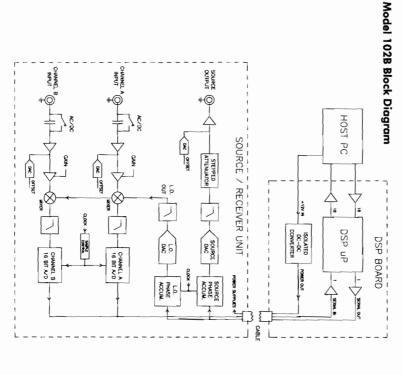
channels

The host PC interfaces with the DSP microprocessor (uP) using the PC's 16 bit data bus. The DSP uP in turn interfaces with the Source/Receiver unit, via a cable, using a high speed bidirectional serial interface isolated from the host PC using differential driver/receivers. The DSP board's isolated DC-DC converter uses the PC's +12v supply as its power source. The converter up and down converts the +12v input to supply the Source/Receiver unit with the needed voltages.

The network analyzer uses a "swept sine" approach to measure the transfer function of the network under test. This approach requires a sinusoidal, variable frequency, source output and two input channels capable of sampling the sinusoidal input over a broad frequency range. The source is of the DDS or direct digital synthesis type which meets the requirements of fast frequency changes, logarithmic or linear sweeps, wide frequency range and low parts count. The receiver is of the heterodyning type which enables a broad frequency range with a fixed low frequency I.F. for high accuracy and low noise analog to digital conversion. The block diagram (below) shows the various stages of the network analyzer in a simplified form.

Both the source and L.O. use a DDS source which functions by accumulating a selectable phase increment at the system clock rate. This accumulated phase value is then directly mapped to the sine value using a ROM lookup table. The sine value is then converted to a voltage using a high speed DAC, the output of which is low pass filtered to remove aliases. The L.O. output is used directly to drive the L.O. side of the receiver mixers. The source output, however, is passed through a stepped attenuator giving 0 to 63 dB's of attenuation. The attenuator's output is then DC offset by a user selected amount and buffered enabling the source output to drive 50 ohm loads.

signal to noise ratio. The amplifiers output drives the signal side of the mixer offset stage then drives an amplifier stage switched by the DSP uP for maximum drives a stage capable of being DC offset for automatic DC offset tracking. The to both. The input signal drives a high impedance input buffer which in turn filtered to remove aliases and sampled by the analog to digital converter. resulting in a mixer output that is a fixed I.F.. The I.F. signal is then low pass The receiver channels A and B are identical thus the following description applies



time, to complex numbers representing the phase and magnitude of the sinusoids at the channel A and B inputs. The DSP uP then passes these complex numbers serial interface. The DSP uP converts the data from both input channels, in real to the PC for error correction and scaling for presentation on the PC's graphics The receiver's analog to digital converter output is sent to the DSP uP over the

display.

APPENDIX B

Measurement Accuracy

The basic accuracy of the analyzer is specified to be 0.025 dB magnitude and 0.1 degrees phase. These specifications assume that a system calibration has been performed after a 30 minute warm-up period at the operating ambient temperature. The analyzer's accuracy can be undermined by changing or swapping the input probes after calibration has been performed.

There are a number of factors that determine the accuracy, or lack thereof (uncertainty or error) of a given frequency response measurement made by the 102B network analyzer. They are listed below in an order which does not necessarily reflect their significance.

Possible error contributing factors external to the analyzer include:

Probe Loading
Probe Compensation
Transmission Line Effects

Possible error contributing factors internal to the analyzer include:

Signal to Noise Ratio
Source Frequency Accuracy
Temperature Drift
Receiver Linearity

To obtain the worst case measurement error the errors from all of these factors need to be summed together as they relate to a given measurement situation. The term 'res', as used in the charts below, indicates the values are below 0.01 dB magnitude or 0.1 degrees phase.

Probe Loading Error

Probe impedance, chiefly capacitance, can cause loading of the circuit under test and can be a significant error source as described in the discussion on high frequency measurements.

Probe Compensation Error

a small screwdriver or adjustment tool set the x10 probe compensation adjustif available, or use a 1:1 cable. Place the other probe in the x10 position. Using forth between channels). Before making measurements perform a frequency manner keeping the probe on its assigned channel (do not swap probes back and ment for maximum flatness. Likewise, adjust the second x10 probe in a similar included probes and should be performed periodically as follows: Select the x1 mum flatness. The adjustment procedure is performed once at the factory on the these probes, several tenths of a dB of error can result from signal level changes of calibration, followed by selecting the appropriate probe attenuation choice in the nect the source and input channels together. Place one probe in the x1 position, V rms signal level output and sweep from 100 Hz to 100 kHz (log sweep). Conprobe attenuation setting in the RECEIVER window. Set the analyzer for a 0.994 can be minimized by adjusting the probe compensation individually for maxibe canceled by performing a frequency response calibration. The linearity error 20 dB, especially in the 0.1 to 10 kHz range. The frequency response error can both a linearity error and a frequency response error. Due to the nonlinearity of RECEIVER window. Ten-to-one (x10) probes, needed for reducing the probe loading effect introduce

Transmission Line Effects

When using coaxial cables at higher frequencies and long cable lengths the transmission line effects give rise to "standing wave patterns" on cables unless the cables are properly terminated at their endpoints with the cable's characteristic impedance. The analyzer's inputs have a one megohm impedance which may need to be terminated to the cables impedance. To avoid this type of error use through-line terminators at the analyzer's input channel BNC's.

Signal to Noise Ratio Error

This error term is labeled "signal to noise ratio" or SNR and is the difference, in dB's, between the analyzer's receiver noise floor and the smallest of the two input channel's signal magnitude. The analyzer's noise floor is specified to be at least 100 dB's below the largest allowable signal which is 1.7 volts rms. An input signal at the worst case noise floor level would then have a magnitude of approximately 18 microvolts rms and the SNR would be 0 dB. The analyzer's typical noise floor

is approximately 5uV rms using a IF bandwidth of 10 Hz. This type of error is a random quantity that manifests itself as trace noise. The chart below lists the measurement error as a function of SNR.

Signal to Noise Ratio Error Charl

Signal Strength	SNR in dB's	Mag. Error (dB)	Phase Error (deg.)
18 uV	0	ω	45
56 uV	10	0.414	13.6
180 uV	20	0.043	5.7
560 uV	30	0.0043 (< res)	1.81
1.8 mV	40	< res	0.573
5.6 mV	50		0.181
18 mV	60	< res	0.0573 (< res)
56 mV or more	70 or more		< res

Source Frequency Error

The source frequency is accurate to 100 ppm (0.01%) or 20 ppm (special) which makes its consideration important only on circuits with extremely high Q such as crystal filters.

Temperature Drift Error

The temperature drift error is due to magnitude and phase changes with the analyzer's internal temperature changing. This results from the operating temperature being different from the temperature at the time the frequency calibration was performed. This error source can be minimized by performing a frequency calibration at the ambient operating temperature after a 30 minute warm-up period. The expected worst case temperature coefficients are 0.0025 dB magnitude and 0.01 degree phase, per degree Celsius.

Receiver Linearity Error

Since the frequency calibration is performed at a single, high, input level any variations in the analyzer's linearity will cause a magnitude error at other, significantly different, input levels. The chart below gives this error as a function of input level.

Receiver Linearity Error Chart

_	_	_	_	
>10 mV	10 mV	1 mV	0.1 mV	Input Signal Level
< res	0.01	0.15	0.30	Magnitude Error in dB's

Output Impedance

-/+ 15 Volts Peak

Voltage at Source Output Absolute Maximum Safe

APPENDIX C

Specifications

	SYSTEM	
PARAMETER Sweep Speed, Per Point ¹ Source/ Receiver Isolation Temperature, Operating Temperature, Storage	TYPICAL SPEC. 4 msec. (66 Mhz 486 PC) 120 dB	MIN. / MAX. SPEC. PC Dependent 100 dB min. 5 °C / 35 °C -40 °C / 70 °C
Temperature, Storage Source/Receiver:		-40 °C / 70 °C
Weight	4.2 lbs.	
Dimensions DSP Card (PC XT size):	2"H x 9"W x 15.5"L	
Weight	0.66 lbs	
Dimensions	4.5"H x 0.75"W x 13.5"L	
	SOURCE	
DARAMETER	TYPICAL SPEC	MIN. / MAX. SPEC.
Frequency Accuracy	100 ppm	20 ppm max.(special)
Flatness, DC to 1 Mhz 2	+/- 0.2 dB	
1 to 15 Mhz	+/- 1.5 dB	
Harmonics	- 40dBc	
Spurious, Exc. Harmonics	- 55dBc	
AC Output Level Range		1.25mV / 1.77V rms
AC Output Level Error 2	5%	
DC Offset Range		-10.128/+10.128 V Peak
DC Offset Error	5%	
Residual DC Offset	10mV	
Current Limit	80mA	
	FO Ohm	

RECEIVER

	7000	
PARAMETER	TYPICAL SPEC.	MIN. / MAX. SPEC.
Dynamic Range ³ < 10MHz	110 dB	100 dB min.
>=10MHz	95 dB	90 dB min.
B/A Magnitude Accuracy ³	+/- 0.025 dB	See appendix B
Abs. Magnitude Accuracy 4	+/- 2%	
Phase Accuracy ³	+/- 0.1 degree	See appendix B
Resolution (IF) Bandwidth	Depends on frequency and	0.01Hz / 1KHz
	Bandwidth selection	
Input Signal Range(AC) ³	5 uV to 1.77 V rms	17.7uV / 1.77 V rms
Input Signal Range(AC+DC)	-12/+12 V Peak	-10/+10 V Peak
A to B Isolation < 10MHz	110 dB	100 dB min.
>=10MHz	95 dB	90 dB min.
Input Imped., x1 probe	1 Megohm	
Input Imped., x10 probe	10 Megohm	
Input Cap., at BNC conn.	22 pF	
Absolute Maximum Safe		-/+ 20 V Peak
Voltage at Receiver Input		

Ratioed measurements cancel source flatness deviations and absolute (1.2/frequency) + 2 ms.

For measurement frequencies > 11KHz. A minimum of 1.2 cycles at the

source frequency are used giving a minimum time per point of

- source level errors.
- Using (IF) bandwidth of 10 Hz or less and 50 sweep Averages.
- With an Absolute Magnitude Full Spectrum calibration as described in Chapter 3.

Specifications subject to change without notice.

APPENDIX D

File Types; Use and Format

Below is a description of the various files which are used by the Network Analyzer Windows software.

nawincon.ini

This file is used to save the setup on program termination. Each time the program is started, the setup configuration is initialized to the values in this file.

Nawincon.ini is located in the windows directory. Although this is a text file, editing is not recommended, Changes can be made by exiting the program with the desired setup parameters (including calibration files). Refer to [File] System Settings...] when changing the hardware port address on the DSP circuit card.

riename.se

Files of extension set are user defined setup files. These files are created using the menu command [File] Save Setup As...]. User setup files have the same effect as nawincon.ini except that they are saved and loaded at any time (also, they are normally saved in the nawincon directory). User setup files are text files with the same format as nawincon.ini. The program maintains four setup files of it's own, these are known as the ampersand-dot-set (&.set) files (mp_&.set, abs_&.set, ci_&.set), iec_&.set). These files are used to save and recall system settings whenever the graph display mode changes.

Filename.dat

Data files. Created with the command [File | Save Data As...] are text files of sweep data. The data is written in the following format: One line per data point, On each line are five (5) tab separated values ordered as Frequency, Magnitude (B/A), Phase (B/A), Absolute Magnitude (A), and Absolute Magnitude (B). Data in this format should be easily imported into most applications.

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Filename.fpl

A Frequency Points List (.fpl) file is used to define specific frequency values for a sweep. The format of this text file is described in detail below (Frequency Point List (FPL) Files).

Warning: iec_50hz.fpl and iec_60hz.fpl are used by the system when in IEC 555-2 display mode and should not be deleted or modified.

Filename.frq, Filename.src, Filename.rcv, Filename.abs

These files are required for system calibration. They are binary files and should not be edited. Creating and loading calibration files is accomplished through the Calibration File Maintenance dialog box. The command [File | Calibration...] opens this dialog box.

Frequency Point List (FPL) Files

As an alternate method of sweeping, NA Windows Connectivity allows a series of frequency values (stored in a file) to be used as the data collection points. These files have the extension .fpl (Frequency Points List) and the format is as follows: An ASCII text file with one frequency value per line. The value may be either decimal or exponential format. It is important that there are no blank lines (even at the top of the file) or extra carriage returns, also, the frequencies must increase from the top of the file on down.

The following is a valid 5 point FPL file

100.38

103.45

1E+4

5.23E+4 800000.9654

The [File] Save Data As...] menu option can be helpful in creating FPL files. Suppose a 400 point logarithmic sweep from 1K to 100K is desired, but the sweep must include the exact value of 10500.00. This can be accomplished by performing a standard log sweep with the limits specified, then save the data to a file (creating a .dat file). By deleting all but the first column in the .dat file and changing the extension to .fpl a 400 point FPL file of the frequency values used in the logarithmic sweep is created. Now find the frequency value closest to 10500.00, +1.05826072562617E+004, and change it to 10500.00. This file can now be used to perform the required sweep.

Default Setup Values

Calibration

Frequency Calibration File

Source DC Null Calibration File Absolute Magnitude Calibration File Receiver DC Null Calibration File

default.abs default.rcv default.src default.frq

Sweep

Sweep Points

Sweep Averaging Factor Sweep Span Sweep Center Frequency Sweep Stop Frequency Sweep Start Frequency Sweep Frequency Input Sweep Mode Sweep Averaging Sweep Type Start / Stop Linear 14,999,990 Hz 7,500,005 Hz 15,000,000 Hz 10 Hz Continuous

Source

Sweep Dwell User Value

0 ms Auto

Sweep Dwell

Source Level Source DC Offset (Fine) Source DC Offset (Source) Source Output 0.0 V 0.0 V 1.25 mV

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Receiver Coupling

Receiver

Receiver BandWidth Receiver Preamp Receiver Attenuation AC 1 Khz

Auto <u>×</u>

(unaffected by default setup)

Colors

 C_{rid} Markers Left Trace

> Dark Green Light Gray

Marker Data Black Right Master Trace Right Trace

Left Master Trace

Light Red Dark Red Dark Blue Light Blue

Data Format

Mag & Phase Frequency Right Trace Left Trace Eng / 2 Std / 2 Std / 2 Exp / 1

Abs Mag Left Trace Frequency

Right Trace

Std / 3 Eng / 2 Std / 3

Exp / 1

Eng/2 Exp/3 Exp/3 Exp/1

Left Trace Frequency

Cmplx Imp

Frequency Left Trace Right Trace Right Trace Eng / 2 Std / 2

Line Frequency 50 F Sensitivity 1 Vo	IEC 555-2 Setup	Display Mode Impo Warning Message Enal	Equivalent Circuit Mode Series	Reference Resistor 100	Complex Impedance Setup	Title Clear	Phase Format +/-	Trace Display Left
50 Hz 1 Volt / Amp Enabled		Impedance (Rect) Enabled	es	1000 ohms		ar	+/- 180°	Left & Right Trace

APPENDIX F

In Case of Difficulty

The host PC is malfunctioning after installing the DSP board.	After starting the analyzer's software the system freezes, not allowing parameters to be entered nor the sweep to be started. The source/receiver unit does not power up, i.e. the red power light is not on when the analyzer's software is running.	SYMPTOM
The port address may conflict with another card in the host PC. Try a new port address and run the analyzer's program again after first deleting the nawincon.ini file.	Make sure the DSP board is plugged into a 16 bit slot (two edge connectors). Verify that the port address on the DSP board matches that entered in the program and does not conflict with other cards. Verify that the DSP board is plugged into the host PC's power supply harness to receive +12v. Verify that the 37 pin cable assembly has been connected to both the host PC and the Source/Receiver unit.	CHECK

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APPENDIX G

Repair and Warranty Information

Repair

If, after reviewing and implementing the diagnostic procedures in appendix F the unit is still non-operational then proceed as follows:

- Contact AP Instruments for further assistance and, if needed, a return authorization.
- [2] Pack the instrument, including all accessories, in the original packing and shipping materials. If the original shipping materials are not available ensure that there is at least four inches of packing material surrounding the instrument and the individual components have been separately wrapped to prevent scratches during shipping.
- [3] Ship the package, insured for full value, to the address obtained in the factory return authorization contact above.

Warranty

The Model 102B comes with a one year limited warranty. During the warranty period, AP Instruments will, at its option, either repair or replace the products that prove to be defective. Should AP Instruments be unable to repair or replace the product within a reasonable amount of time, a refund of the purchase price may be given upon return of the product.

Warranty Exclusions

The warranty on your Model 102B shall not apply to defects resulting from:

- Customer supplied software or interfacing.
- Damage by accident or abuse.
- Unauthorized modifications or misuse.
- Operation outside the environmental specifications of the product.

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APPENDIX H

Source Fuse Replacement

can be the result of a blown source protection fuse. The protection fuse is a LITTLEFUSE PICO II 0.125 Amp Fast Blow part number 251.125. flowing into the analyzer source output stage. The lack of output from the source The Model 102B's source is fused to protect against an excessive external current

circuit board next to the source output BNC connector. located directly behind the source BNC and are wider than the receiver shields moved at which point the shields can be removed. The source shields are bottom cover followed by removing the inner six screws on each side of the bottom covers. This is accomplished by first removing the three screws on the Replacing the fuse first requires removing the source/receiver unit's top and 102B's case. The 14 cap screws retaining the source shields must then be re-The fuse has a reference designator of F1 and is located near the front of the This fuse is located under the source shield for serial numbers less than 2350

of the 102B's case. A socketed spare fuse, located to the side of the source BNC shields. Replacing the fuse first requires removing the source/receiver unit's top connector, is available for serial numbers greater than 2349. cover. This is accomplished by removing the top inner three screws on each side For serial numbers greater than 2349 the socketed fuse is located immediately behind the source output BNC connector and is accessible without removing the

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Preventing Blown Fuses

should suffice to keep the source current below 50 mA in case of a of exposed voltage. For example a 300 Ohm resistor in series with the source occurring it is recommended to ensure a source impedance of 20 ohms per vol which resulted in excessive current into the source output. To prevent this from tions before powering down the circuit under test. misconnection to a \pm 1-15v potential. Make sure the analyzer is powered up before connecting to powered circuits. Likewise, remove the analyzer connec The source protection fuse blows if the circuit under test had voltage potentials

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